RESEARCH DEPARTMENT

A U.H.F. amplifier and distribution unit

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RESEARCH DEPARTMENT

A U.H.F. AMPLIFIER AND DISTRIBUTION UNIT

Technological Report No. G-089

(1964/16)

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SUMMARY

This report describes a simple single-transistor u.h.f. amplifier suitable for use either as a low noise pre-amplifier for a receiver or as a mast-head amplifier remote from the receiver. The amplifier, with a gain of 12 dB, can be made for use at any single Band IV or V television channel.

A bridge distribution unit is also described which enables the output of the amplifier or other u.h.f. source to be split into four matched outputs without further loss in resistive components.

1. INTRODUCTION

At u.h.f. feeder loss can be quite high and is frequently a serious limitation in receiving systems. In most cases the importance of this loss lies not merely in the reduction of signal but in the increase of the noise factor of the installation, since this is given by the sum of the receiver noise factor and the cable attenuation expressed in decibels.* This can be alleviated by the use of a low-noise amplifier as near to the aerial as possible and, if necessary, at other points in the system. It is often convenient for the amplifier to be supplied with power via the output cable, thus simplifying the installation of an amplifier at a remote point.

Distribution systems often require the output from one aerial to be split in order to feed several outlets. If these outlets are simply paralleled then, at the junction point, there must be a mismatch as seen from one side or the other, even if a matching transformer is used. This mismatch can be avoided by the use of resistive networks but this leads to extra loss. Since both mismatch and loss are undesirable, a distributor incorporating a bridge circuit was produced. This distributor gives four outlets from two independent inputs, one of which may be a dummy load. If all inputs and outlets have the correct termination then they are all correctly matched in both directions and the loss will be a minimum (6 dB) for a resistive network.

* This assumes that the cable is at standard room temperature (288°K).

2. AMPLIFIER CIRCUIT DESCRIPTION

The amplifier uses a single u.h.f. transistor (Philco T2872) as a grounded-base amplifier, and the circuit diagram of the version designed for use in a distribution system is given in Fig. 1. The transistor is mounted in a small hole in the wall between the two halves of its screening box. The input is matched to the emitter of the transistor by a line 0·31λ long (where λ is the wavelength in the

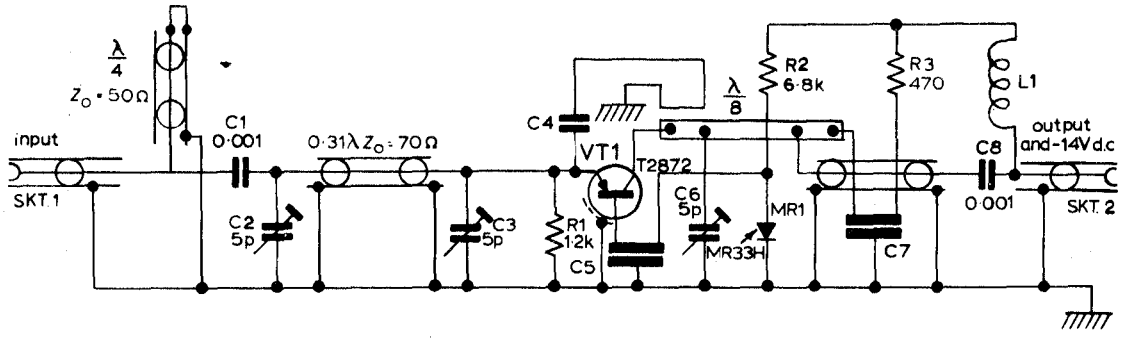


Fig. 1 - Circuit diagram of u.h.f. amplifier

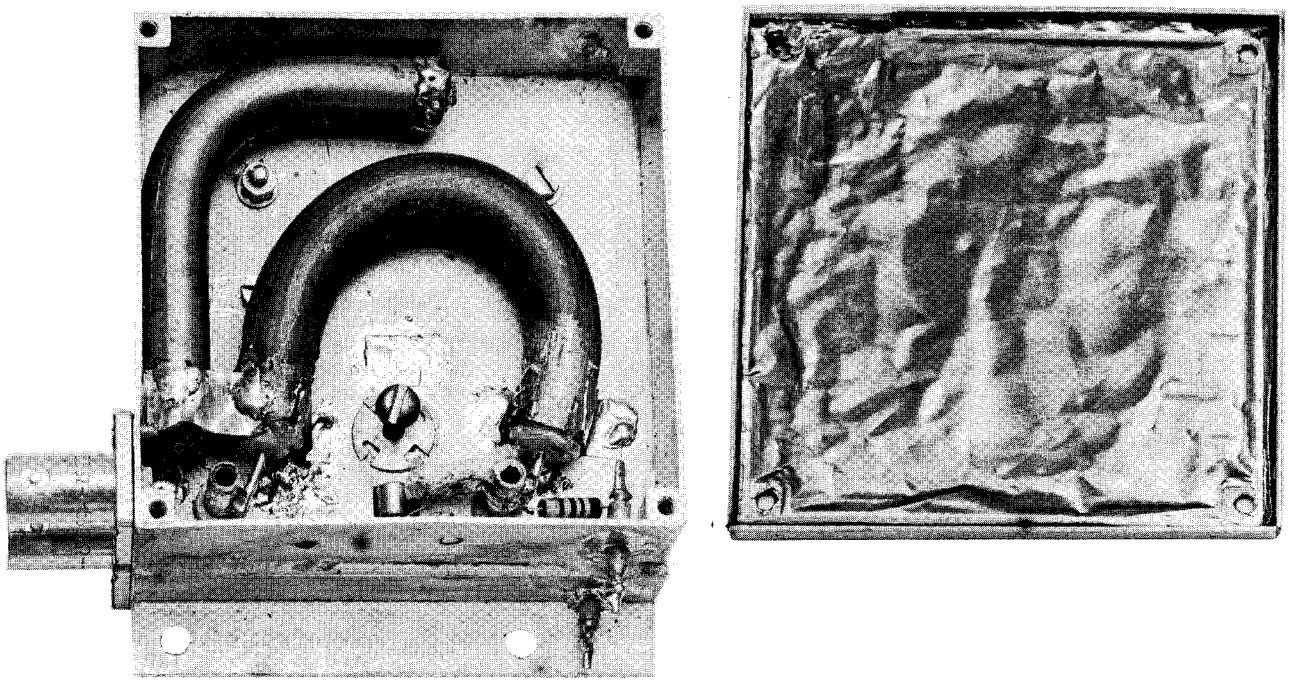
line) with a trimmer at each end. The range of adjustment of these trimmers is sufficient for either 50 or 75 ohms input impedance. This input circuit gives little rejection of frequencies below the operative frequency and, in order to avoid interference from unwanted signals at a high level, a quarter-wave short-circuited line is connected across the input socket. Lead-covered cable is used for the input lines to give good mechanical stability.

The collector circuit consists of a λ/8 line tuned by a trimmer at the collector. The output is tapped on to the line near its short-circuited end and adjusted to give the required output impedance. This collector line consists of a copper strip mounted near the chassis, the spacing being adjusted to give a characteristic impedance of 110 ohms.

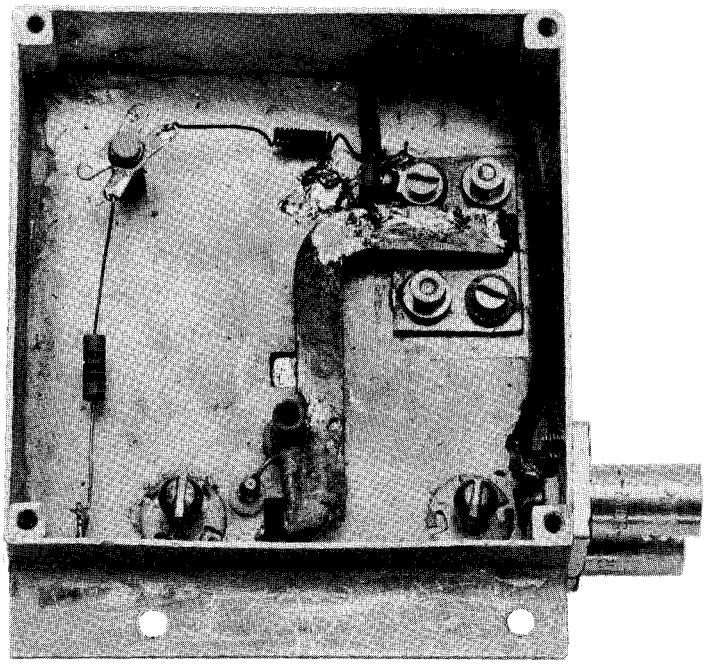
The inherent feedback within the transistor is neutralized by a loop inductively coupled to the collector line and capacitively coupled to the emitter. If this neutralizing is omitted, the gain increases by up to 6 dB and, although the amplifier remains stable, it becomes difficult to match the input circuit.

In the distribution amplifier, a 14V supply, negative with respect to the screens, is fed into the output cable as shown in Fig. 1, and the transistor base is stabilized at -3·3V by a Zener diode MR1. A simple modification to the amplifier can also enable it to pass on the d.c. power supply to the input cable in order to facilitate tandem connexion of two or more units.

In an alternative amplifier designed for use with u.h.f. field strength measuring receivers,[1] separate d.c. power supplies are provided to the amplifier, the base of the transistor being directly grounded. A photograph of an amplifier of the latter type is shown in Fig. 2.



(a) Input side



(b) Output side

Fig. 2

Views of amplifier

3. AMPLIFIER PERFORMANCE

The amplifier can be adjusted for either 50 or 75 ohms input or output impedance. Over a frequency band of 8 Mc/s it has an input v.s.w.r. of better than 0·9 and an output v.s.w.r. of better than 0·8, with, as shown in Fig. 3, a gain

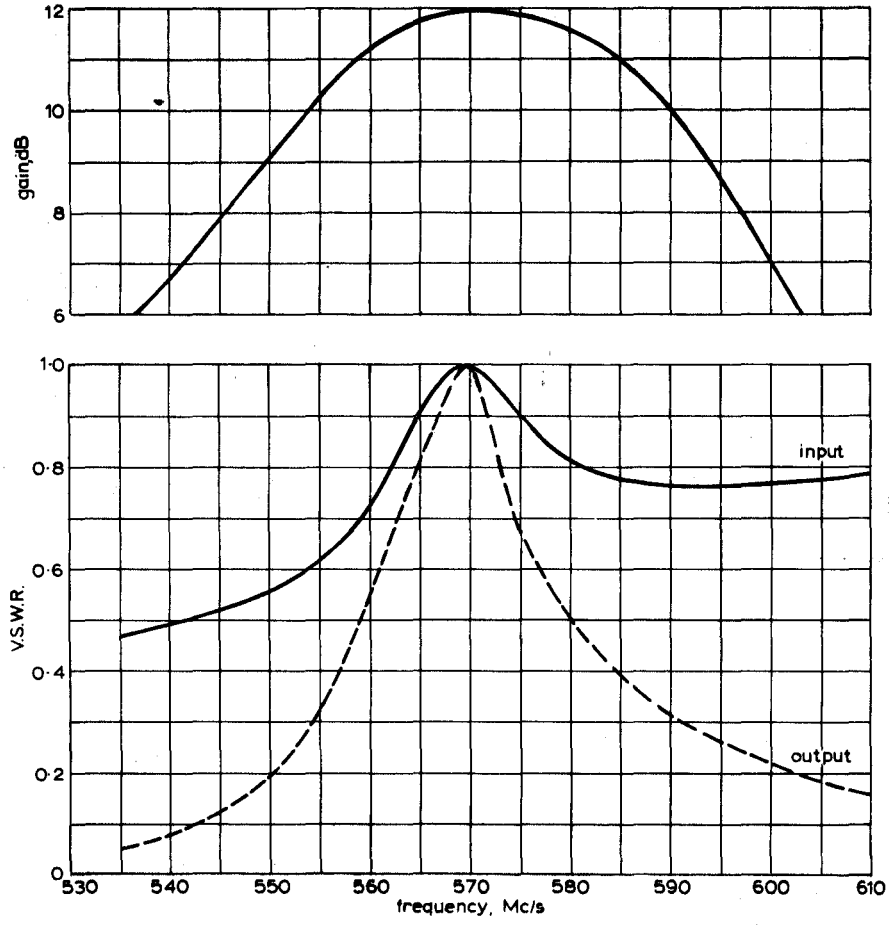


Fig. 3 - Variation of gain and input and output v.s.w.r. with frequency

constant to within ¼ dB. The '3 dB bandwidth' is greater than 40 Mc/s. The mid-band gain is approximately 12 dB, increasing by ¼ dB at -10°C and falling by ½ dB at +45°C. The maximum input signal level should not exceed 50 mV. The noise factor of the amplifier alone is approximately 8 dB.

With suitable line lengths the amplifier can be tuned to any frequency in the range 470 - 850 Mc/s with little change in performance.

When the amplifier is fitted into a u.h.f. field strength measuring receiver[1] provided with a narrow band (± 15 kc/s) i.f. unit, input signals of less than 0·5 μV may be measured by the receiver.

4. THE BRIDGE DISTRIBUTION UNIT

The bridge circuit of Fig. 4 is balanced if all the resistors are equal. Among the many properties of a bridge in this condition, the ones of particular interest are:

(a) Each resistor is shunted by a resistance equal to its own value.

(b) There is no coupling between resistors AB and CD, AD and BC, AC and BD.

(c) If any resistor is replaced by a source, then with the exception of the resistor which is decoupled according to (b) the other four resistors dissipate equal powers, each equal to one quarter of the power delivered by the source.

If the resistors of Fig. 4 are replaced by coaxial cables as in Fig. 5, the above properties still hold if the cables are matched. Since some of the outer conductors require to be connected together, they may be grouped as shown in Fig. 5,

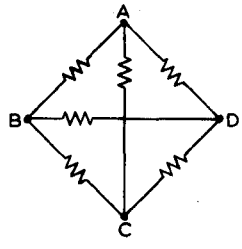


Fig. 4
Bridge Circuit

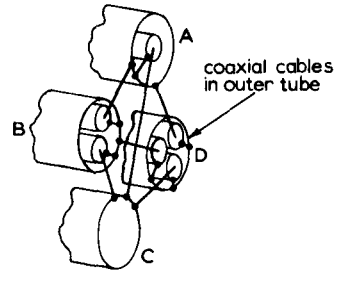


Fig. 5 - Practical arrangement of bridge circuit using lines

each group being mounted within a tube, the outer conductors being bonded to the tubes. Ideally the ends of the tubes require to be isolated from one another by very high impedances. In a practical arrangement a short circuit is placed at $\lambda/4$ from the ends of the tubes. With this arrangement the current flow at the ends of the tubes will be small and the unwanted loading of the bridge circuit will be negligible. At frequencies removed from this resonant condition some loading of the lines occurs, but a v.s.w.r. of better than 0·95 is obtainable at u.h.f. over a bandwidth of ± 50 Mc/s.

A photograph of a practical bridge distribution unit is shown in Fig 6.

The bridge distribution unit may be used to combine two separate signals, using the two input terminals which have no mutual coupling. It should be noted that the phase relationship between the two signals will differ at the different outlets, but this is generally of no consequence when signals of different frequencies are combined.

When only one input is required, one cable may be replaced by a resistor as in Fig. 7. This circuit also shows a simple way of feeding d.c. to the input cable in order to supply an amplifier of the type shown in Fig. 1. A bypass capacitor is required as shown in Fig. 7.

5. PRACTICAL DISTRIBUTION SYSTEMS

In a practical distribution system a pre-amplifier would be connected directly to the aerial terminals, and would obtain its power supply viâ the output cable. Such an amplifier would overcome the loss in the main feeder to a central

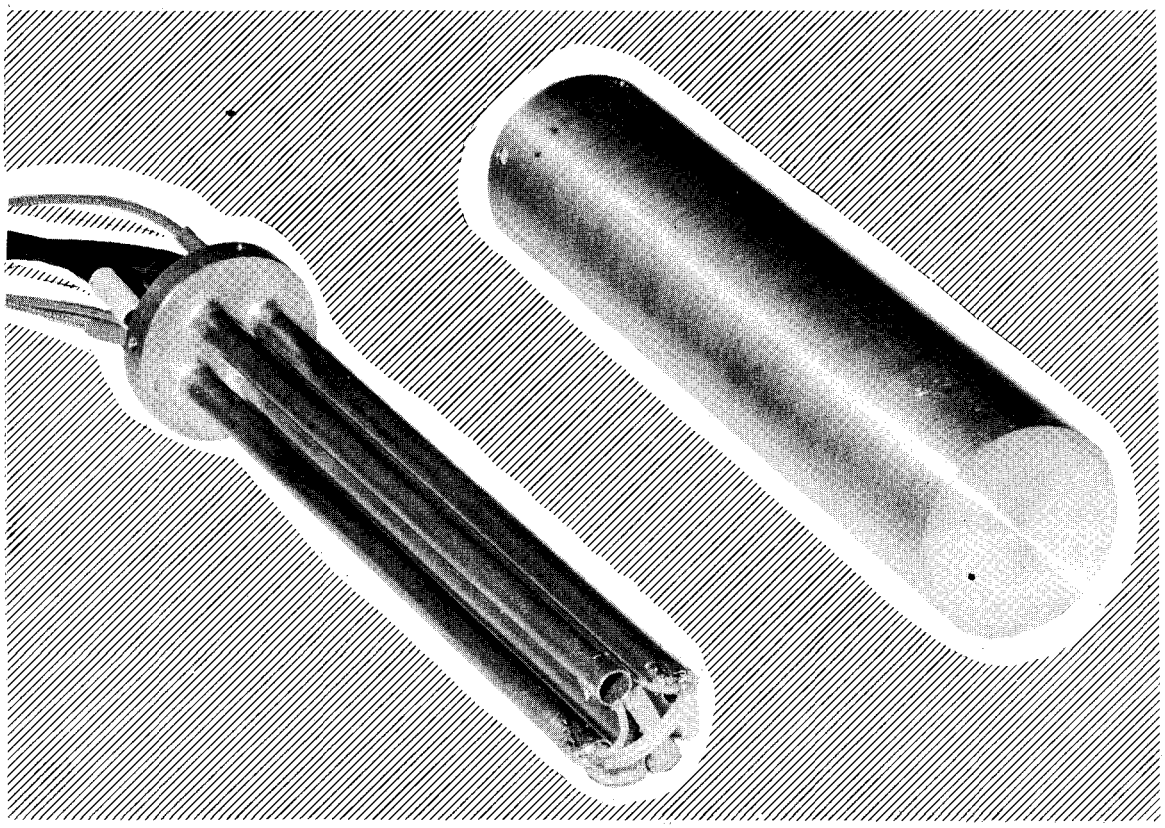


Fig. 6 - Photograph of bridge distribution unit

distribution point where one or more additional amplifiers would be employed, followed by bridge distribution units.

These distribution units are connected to the final outlets by cables. The loss in each of these connexions, either in the cables alone or with the addition of attenuators, is preferably arranged to be about 10 dB in order to reduce the undesirable effects of any mismatch at the outlets during normal laboratory use. Sufficient amplification should, of course, be provided in the system to allow for this so that, with typical receivers, the receiver noise does not appreciably degrade the signal-to-noise ratio available from the system.

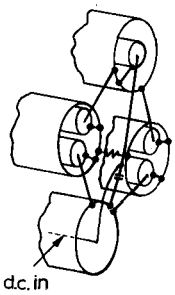


Fig. 7
Bridge arrangement with facilities for sending power to a u.h.f. amplifier

6. CONCLUSIONS

A u.h.f. transistor amplifier can be made with a sufficiently low noise factor to give a useful improvement in sensitivity when used in conjunction with a u.h.f. receiver of average performance. Amplifiers of this design can also be combined with bridge distribution units to form the basis of a u.h.f. distribution system.

7. REFERENCE

1. 'V.H.F. Field Strength Measuring Receivers', Research Department Report No. K-164, Serial No. 1963/43.

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